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### DIAMOND CUTTING ACCELERATED BY ELECTRIC ARC

The method universally employed for cutting plane surfaces or facets on diamonds has been to place the diamond in contact with a flat cast-iron lap, charged with diamond powder and rotated at about 2,000 revolutions per minute. As a general rule, cutting is most rapid when the plane of the facet is parallel to one or two of the crystal axes of the diamond and the direction of motion of the lap surface is parallel to one of the axes. For other orientations, the cutting rate decreases until, on an octahedron face, which is approximately at 35 degrees to all three axes, cutting is next to impossible. C. G. Peters, chief of the Bureau's interferometry section, has found that by producing a high-voltage electric arc at the contact between the diamond and lap, the cutting rate is very materially increased for all orientations of the facet. The dop that holds the diamond is connected to one of the secondary terminals of a 5,000-volt power transformer and the rotating lap to the other. When the 110-volt alternating current is applied to the primary of the transformer and the primary current is adjusted to about 0.5 ampere,

a small blue arc is formed at the contact of the diamond and lap.

The arc about doubles the cutting rate for the most favorable directions, and increases the rate about four times for the least favorable directions on the cube and dodecahedron faces. The cutting rate on the octahedron faces is about the same as that for the least favorable directions on the cube or dodecahedron faces. By applying the arc to a diamond saw, the sawing rate is greatly increased; and diamonds can be sawed regardless of the orientation of the cut relative to the crystal axes.

A complete description of the method will appear in a forthcoming number of the Journal of Research. Announcement of the Research Paper number and price will be made, as usual, in this Bulletin.

### EFFECT OF POLISHING THE BASE METAL UPON PROTECTIVE VALUE OF ELECTROPLATED COATINGS

It is a common belief that if metals are plated upon a rough metal surface, the deposits are likely to be more porous than on smooth surfaces, and hence to furnish less protection against the cor-

<sup>1</sup> Published with approval of the Director of the Budget.

rosion of the base metal. An investigation was conducted by Gerald A. Lux, research associate of the American Electroplaters Society, and William Blum of the Bureau's electrochemistry section to determine what effects are produced upon the protective value of coatings by differences in the degree or method of polishing the base metal.

The first phase of the investigation, which is reported in the April Journal of Research (RP1645), was confined to the plating of copper, nickel, and chromium on strips of cold-rolled steel that had been polished, principally with glued abrasive wheels having abrasives of known grain size. The specimens were then plated with definite thicknesses of copper, nickel, and chromium and exposed to the atmosphere in New York, N. Y.; Sandy Hook, N. J.; and Washington, D. C. They were inspected at intervals and rated according to the extent of rust.

The steel was polished with abrasive grains (sizes from 90 to 320), and some specimens had a "superfinish," applied by polishing with fine abrasive and oil. The surface finish on the various polished steel specimens was measured with a Profilometer and expressed as the root mean square of the depth of scratches, in microinches. Valuable data were obtained regarding the effects of polishing upon the surface finish and upon the amounts of metal removed.

The exposure tests showed that the wide differences in the surface finish produced practically no effects upon the protective value of the coatings. Results in accelerated tests, such as the salt spray, were less reproducible and consistent than in the atmospheric tests. The failure to observe effects of polishing may be accounted for by the use in this study of a high-grade cold-rolled steel that had less inclusions than may be present in hot-rolled steel. It is planned to extend the study to include other grades of steel, and also brass and zinc-base die-castings.

#### CATHODIC PROTECTION OF PIPE LINES

In order to study the effectiveness of zinc anodes for the cathodic protection of iron and steel under various soil conditions, zinc-iron couples were buried at eight test sites under the Bureau's auspices in 1941. Measurements of the current and potential were made on the couples at the time of installation and at subsequent inspection periods. In general, the currents have been maintained during the period covered by the tests. At two sites, the current re-

quired to protect the iron cathodically was measured. Couples were removed from two sites and cleaned, after which the loss in weight of each element was determined. Coupling to zinc reduced somewhat the corrosion of the iron for 1.5 years in a soil containing sodium carbonate, but the degree of protection cannot be considered adequate. At the other site the iron was almost completely protected galvanically during the exposure period of 3.14 years.

The complete report on this work, by Melvin Romanoff, will be published in the Proceedings of the National Association of Corrosion Engineers.

#### ADVANTAGES OF THICK-WALLED PIPE

Improvement in materials and methods of manufacturing pipe has made it possible to use less metal in the construction of a pipe line. However, as Kirk H. Logan points out in an article that he has prepared for publication in "Petroleum Engineer," it must be remembered that the newer pipes, though as strong or stronger than the old ones, do not last as long because the resistance of the metal to corrosion has not been improved, and the pipe walls are thinner. The usefulness of thin-walled pipe can be prolonged in several ways, as, for instance, by the application of a coating or cathodic protection or by surrounding the pipe with sand or non-corrosive soil.

In many soils the rate of corrosion declines as exposure is prolonged; in such cases, a small increase in the thickness of the wall of a pipe will result in a large increase in the time required for the development of a puncture by corrosion.

Mr. Logan discusses the advantages of several methods of extending the usefulness of pipe lines and shows that the choice of the method should be governed by the character of the soil to which the pipe is to be exposed.

#### FIRE-EXPOSURE TESTS OF BUILDING CONSTRUCTIONS AS RELATED TO ACTUAL FIRES

In the standard fire-resistance test of building constructions, the prescribed furnace temperatures are generally at higher levels than for fires that occur in actual buildings. However, it has been indicated that substantially the same temperature rise is obtained on the unexposed side of a construction if the product of time by temperature, that is, the area under the fire-exposure curve, is the same. To obtain further infor-

mation on this point, a refractory slab was subjected to carefully controlled exposures to uniform temperatures in the range 700° to 1,300° F. and the rise in temperature on the unexposed side noted. It was found that within this range a rise of 250 degrees Fahrenheit on the unexposed side was obtained for very nearly the same time-temperature area, the variations being within experimental error.

It was also indicated by the results (as also from theoretical considerations) that, assuming no change in the thermal properties of the construction, the ratio of temperature rise on the unexposed surface to hot-side temperature is a function of time only and does not depend on temperature. Hence it was possible by mathematical methods to apply the results obtained at constant hot-side temperatures to the solution for conditions where these vary with time as they do in furnace tests and in exposures of constructions to fires in buildings.

#### SOUNDNESS TEST FOR HYDRATED LIMES

A few years ago, as a result of an investigation at the Bureau of a particular kind of plaster failure which is characterized by the formation of bulges in the finish surface, manufacturers of lime started to convert their hydrating plants to produce a finishing and masonry lime in which the magnesia was more nearly completely hydrated. The war, with its demand for steel and other critical materials, has delayed the conversion. Therefore, there is still a need for a performance test to differentiate hydrated limes that can cause a marked expansion from those giving little or no expansion. An investigation has been undertaken to develop an accelerated autoclave test for this purpose and the test procedure has been formulated.

Fifty-seven different samples of hydrated lime, representing a fair cross section of the types produced, have been mixed with one brand of portland cement, cast into bars, and the expansions of the bars determined. Very good checks have been obtained by two different operators using two different autoclaves. Other brands of cement now are being used. Although, in general, the bulk of the limes, when tested with different cements, give expansions in sufficiently close agreement after corrections are applied for the expansion of the cement, there are a few limes that, with different cements, give expansions having a greater spread than is desired.

It is hoped that the cause of this can be found and that this spread can be eliminated or reduced.

#### MELTING POINT OF ALPHA- ALUMINA

The value usually quoted in the literature for the melting point of alumina ( $\text{Al}_2\text{O}_3$ ) is 2,050° C., which was published by C. W. Kanolt in 1914. Several investigators have since published values ranging from 2,001° to 2,045° C.

Alumina is not only an important constituent in many industrial products but has become essential in super-duty spark-plug insulators, refractories for special high-temperature applications, and also for insulators in the field of electronics. Also, a large number of systems which have been, or are being, investigated for the determination of phase relations include alumina as one of the end members. Consequently, it was considered important to attempt again the establishment of the true melting point of alumina of high purity and under carefully controlled conditions.

Three samples were available, all of which contained over 99.9 percent of  $\text{Al}_2\text{O}_3$ . The specimens were heated in an oxidizing atmosphere, and under atmospheric pressure, by the use of a furnace in which an electric current, passed through resistors made of thoria and ceria, produced the necessary temperature. The heating rate changed from 1 to 5 degrees centigrade a minute, and observations were made with an optical pyrometer.

In seven tests, the minimum temperature at which melting was seen to begin was 1,990° C. and the maximum was 2,010° C. Although spectrographic analyses of four of the specimens, made after the melting tests, showed that they had "picked up" measurable impurity from the furnace atmosphere, especially silica and magnesia, the indications are that these melted materials contained about 99 percent of  $\text{Al}_2\text{O}_3$ .

As a result of these tests, which were made by R. F. Geller and P. J. Yavorsky and are reported in the April number of the Journal of Research (RP1649), it is believed that alumina melts within the range 2,000° to 2,030° C.

#### HEATS AND FREE ENERGIES OF FORMATION OF THE PARAFFIN HYDROCARBONS

The latest joint report of the Bureau's thermochemical laboratory and the American Petroleum Institute Research Project 44 will appear as RP1650

in the April number of the Journal of Research. This report, which has been prepared by Edward J. Prosen, Kenneth S. Pitzer, and Frederick D. Rossini, gives values for the heats of formation and the free energies of formation, from solid carbon (graphite) and gaseous hydrogen, of all the normal paraffin hydrocarbons and of the isomeric paraffins from the butanes through the octanes, in the gaseous state, to 1,500° K.

#### **FREEZING TEMPERATURE OF BENZOIC ACID AS A FIXED POINT IN THERMOMETRY**

Exact measurements of temperature in the range of nearly -200° to nearly +700° C are based on the change with temperature of the electrical resistance of a coil of fine platinum wire; the device used for this purpose is known as a resistance thermometer. To standardize the instrument, measurements of its resistance must be made at three fixed temperatures if it is to be used in the range above zero and at four temperatures if the lower range is also to be covered. The four fixed temperatures commonly used for the standardization are the normal boiling point of oxygen, -182.97° C, the melting point of ice, 0° C, the normal boiling point of water, 100° C, and the normal boiling point of sulfur, 444.60° C.

For many purposes, the melting point of ice and the normal boiling point of water are the more important of these fixed points. Of these two, the melting point of ice can be quite easily reproduced with high accuracy, but accurate observations of the boiling point of water are much more difficult to make. This is because boiling points fluctuate markedly with changes in barometric pressure. Even with the painstaking barometric measurements practiced in standardizing laboratories, the "steam point" cannot be observed as accurately as the "ice point." In distinction from boiling temperatures, melting or freezing temperatures are only slightly affected by variations in barometric pressure. Therefore, substituting a suitable freezing temperature for the "steam point" would simplify the standardization of resistance thermometers and, if such a temperature were sufficiently reproducible, might improve the accuracy of standardization.

In Technical News Bulletin 315 (July 1943) a preliminary report was presented on the use of the freezing point of benzoic acid as a thermometric fixed point. Results of subsequent work by

Frank W. Schwab and Edward Wichers, including extended observations on the freezing point, and suggestions for the use of this point in the calibration of thermometers instead of the "steam point," are presented as RP1647 in the April Journal of Research. The purified acid is contained in a sealed glass cell provided with a thermometer well in which the instrument to be standardized can be inserted. When the acid is melted and then allowed to start freezing in the cell in a suitable manner, a very constant temperature is maintained while the acid freezes. The freezing temperature is 122.36° C. It may differ by a few thousandths of a degree between cells of a group, depending upon the purity of the acid and the conditions existing within the cell, but is fixed to within one-thousandth of a degree in a particular cell. Plans have been made to issue this type of cell with a certified temperature for use in calibrating thermometers in scientific and industrial laboratories.

The paper includes observations on the freezing temperature of benzoic acid under various conditions, on the change in volume which occurs when the acid freezes, on the solubility of oxygen and nitrogen in the liquid acid, and on the stability of the acid during prolonged heating at temperatures above its freezing point. There is an appendix, by Frank W. Schwab and E. R. Smith, on a method of calculating temperatures from observations of the resistance of platinum thermometers.

#### **pH OF PHOSPHATE SOLUTIONS**

Mixtures of potassium dihydrogen phosphate and disodium hydrogen phosphate in aqueous solution form a very satisfactory series of standard buffers with pH values near the neutral point (pH 7). When these buffers are diluted to twice their volume with pure water, the pH is changed less than 0.1 unit. The selection of these two salts in preference to other primary and secondary phosphates is dictated by such desirable properties as ease of purification, stability, and low hygroscopicity.

In an earlier study of phosphate buffers, Roger G. Bates and S. F. Acree determined the second dissociation constant of phosphoric acid and the pH of several mixtures of sodium phosphates and sodium chloride from electromotive force measurements between 0° and 60° C. In a paper (RP1648) published in the April Journal of Research, these authors now report an extension of the work to a study of the series of phosphate buffers composed

of equal molal quantities of potassium dihydrogen phosphate and disodium hydrogen phosphate. A method for determining the pH of the buffer without chloride is outlined. Five series of buffer mixtures containing different amounts of sodium chloride were prepared and their pH values were determined from measurements of cells without liquid junctions. The change of pH with content of sodium chloride was obtained, and a calculation of the pH of the chloride-free buffer was made. The pH at 25° C ranges from 6.67 to 7.02. The values for the dissociation constant at 0° to 60° C published earlier are confirmed. Equations are given to represent the salt effect, or change of pH with amount of added sodium chloride, at each of the 13 temperatures. Addition of this salt was found to lower the pH in each case.

#### PHOTOMETER FOR LUMINESCENT MATERIALS

The phosphorescent materials, familiar to many as novelty hair ornaments, nursery pictures, and small toys for the amusement of children, also have some very practical uses. The calcium, strontium, and zinc-sulfide materials have been found well suited for marking escape panels, important controls, companion ways and obstacles in the interior holds, cargo spaces, and cabins of ships. The measurement of the brightness these materials yield requires a special technic and equipment. The datum and a photometer for measuring the brightness of luminescent materials are described by Ray P. Teele in a paper (RP1646) in the April number of the Journal of Research.

#### PRECISION OF RATING MOTOR FUELS

The knock ratings of motor fuels are determined by standardized tests in a specified engine, the results being expressed as octane number. Fuel of too low a rating will cause heavy detonation, will reduce performance, and may cause engine failure. On the other hand, fuel of unnecessarily high rating would waste components needed for aviation gasoline. As fuel for military ground vehicles is purchased on octane number specifications, the importance of precise rating is obvious.

Since 1933 the Bureau's automotive section has been analyzing data obtained by a large group of laboratories in the duplicate rating of monthly exchange samples of motor fuels. The triennial analysis for 1942-44, just com-

pleted, shows that the precision of rating has deteriorated materially since early in 1942, and now is poorer than at any time during the past decade. This deterioration was presumably caused by loss of experienced operators and maintenance men or by their transfer to the more critical rating of aviation fuels. The precision of rating is now so poor that if procurement of fuels is to be based on a single acceptance rating, the specification must be set one and one-half octane units above the minimum acceptable value to assure obtaining fuel of the desired quality. It appears certain that the loss of precision would have been even greater were it not for the additional safeguards to testing, established during this period by the work of the Coordinating Fuel Research Committee, in which the automotive section has participated actively.

#### VINYL PLASTIC SHOE SOLES

The public has heard and seen a great deal of plastic soles during World War II. The critical supply situation with respect to sole leather, attributable to increased demands by the military services and dependence to a large extent on foreign sources for hides and tanning materials, has made it necessary to seek replacements wherever possible. One type of material that has been found to have suitable properties for this application is vinyl resin. Unfortunately, this synthetic material is also in very critical supply. However, scrap available from the manufacture of insulation for wire and cable has been employed for the production of shoe soles.

Twenty-two vinyl plastic materials for shoe soles were evaluated by G. M. Kline, P. A. Sigler, and P. Plala at the Bureau in an investigation undertaken for the War Production Board. The materials were obtained from various manufacturers during the period December 1943 to February 1944. The properties measured were thickness, density, tensile strength, elongation at break, stitch tear, change in thickness on immersion in water, loss in weight on heating, flex-fatigue life at 32° F, resistance to cracking on bending at 0°, -20°, and -40° F, and abrasion resistance.

The vinyl plastics were inferior to leather in tensile strength and stitch tear, but were superior to leather in change in thickness on immersion in water and abrasion resistance. On the basis of these tests it is concluded that the more satisfactory grades of vinyl plastic shoe sole materials would meet the following requirements: Tensile strength (minimum) 1,500 lb/in.<sup>2</sup>;

stitch-tear strength, dry and wet (minimum) 30 lb, irrespective of the thickness of material; flex-fatigue life at 32° F (minimum) 1,000,000 cycles; bend test at 0° F, aged and unaged (minimum) 10 bends over a 1/2-in.-diameter mandrel; abrasion resistance, leather machine (minimum) 6,000 revolutions per millimeter; abrasion resistance, Taber machine (maximum) 75 milligrams per 1,000 revolutions.

The materials meeting the above requirements did not contain fibrous fillers. This is particularly worth noting in view of the many cracking failures which have been experienced with soles made of large amounts of fibrous materials bonded with small percentages of resin. These so-called "plastic" soles are akin to the rabbit meat made with one rabbit and one horse.

If the sole is to be attached to the shoe by stitching only, the stitch tear requirement of 30 lb may not be adequate. Higher stitch tear strength can be obtained by the use of a fabric backing material.

#### REVISED SIMPLIFIED PRACTICE RECOMMENDATION FOR ABRASIVE GRAIN SIZES

The proposed revision of Simplified Practice Recommendation R118-43, Abrasive Grain Sizes, has been accorded the required degree of acceptance by manufacturers, distributors, and users; it will be identified as R118-45, effective from April 1, of this year.

The recommendation covers a simplified schedule of grain sizes for aluminum oxide and silicon carbide abrasives for grinding and polishing uses and for grinding wheel manufacture. The proposed revision includes an increase in the allowable oversize in No. 46 grit from 20 to 30 percent, and the inclusion of No. 240 grit. These changes are the first to be made in the table of grain sizes since 1930, when the recommendation first became effective. It was reissued in 1936 and 1940 when changes in the text were made without affecting the original schedule.

Mimeographed copies of R118-45 may be obtained, upon request, from the Division of Simplified Practice, National Bureau of Standards, Washington 25, D. C.

#### HANDBOOK ON TESTING WEIGHING EQUIPMENT

Methods of inspection and tests for various types of scales and weights are

presented in comprehensive yet compact form in Handbook H37, Testing Weighing Equipment by Ralph W. Smith, which has just been published. Although intended primarily for the use of weights and measures officials, the information should prove useful to persons employed in maintaining the weighing equipment of commercial and industrial establishments. It represents many years of experience at the Bureau and in the field, as brought out at conferences and in committee recommendations.

As one of a series of publications on weights and measures supervision, of which two entitled Weights and Measures Administration and Specifications, Tolerances, and Regulations for Weighing and Measuring Devices have been issued, it was originally planned that the third Handbook would discuss methods of inspection and test for all types of commercial weighing and measuring devices rather than weighing equipment only. However, war conditions have interfered with the work to such an extent that it was deemed advisable to publish the material now on hand.

It is not the duty of the weights and measures officer to do repair work; hence the text is basically restricted to a discussion of methods of making inspections and tests. However, since a knowledge of fundamental principles of operation is essential if testing is to be done intelligently, brief elementary discussions of these principles are included.

Outlines of steps to be followed in the recommended test procedures are tabulated in proper sequence. Necessarily, the treatment of the many kinds of commercial apparatus must be by general type only, but if the basic principles of each type are borne in mind, no difficulty should be experienced in adapting the test routine to all the equipment encountered.

Three appendices follow the nine chapters of the text. The first gives a schedule of equipment for field use, including vehicle scale testing equipment and that for general purposes; the second is made up of weights and measures tables, including metric weights and measures, interrelation of units of measurement, and tables of equivalents; and the third gives citations to publications, issued by the Bureau and elsewhere, for study and reference.

Copies of the Handbook, bound in buckram, are obtainable from the Superintendent of Documents, Government Printing Office, Washington 25, D. C. The price is 75 cents.



**NEW AND REVISED PUBLICATIONS ISSUED DURING MARCH 1945**

**Journal of Research<sup>2</sup>**

Journal of Research of the National Bureau of Standards, volume 34, number 1, January 1945 (RP1624 to RP1630, inclusive). Price 30 cents. Annual subscription, 12 issues, \$3.50.

**Research Papers<sup>2</sup>**

[Reprints from December 1944 Journal of Research]

RP1618. Standard response functions for protanopic and deuteranopic vision. Deane E. Judd. Price 10 cents.

RP1620. Heat of formation of carbon dioxide and of the transition of graphite into diamond. Edward J. Prosen, Ralph S. Jessup, and Frederick D. Rossini. Price 5 cents.

**Handbook<sup>2</sup>**

H37. Testing of weighing equipment. Ralph W. Smith. Price 75 cents.

<sup>2</sup> Send orders for publications under this heading only to the Superintendent of Documents, Government Printing Office, Washington 25, D. C. Subscription to Technical News Bulletin, 50 cents a year; Journal of Research, \$3.50 a year (to addresses in the United States and its possessions and to countries extending the franking privileges); other countries, 70 cents and \$4.50, respectively.

**Technical News Bulletin<sup>2</sup>**

Technical News Bulletin 335, March 1945. Price 5 cents. Annual subscription, 50 cents.

**MIMEOGRAPHED MATERIAL**

**Letter Circulars**

[Letter Circulars are prepared to answer specific inquiries addressed to the National Bureau of Standards and are sent only on request to persons having a definite need for the information. The Bureau cannot undertake to supply lists or complete sets of Letter Circulars or send copies automatically as issued.]

LC780. Methods of using standard frequencies broadcast by radio. (Supersedes LC751.)

LC782. Plastics; A short list of selected publications. (Supersedes LC712.)

**RECENT ARTICLES BY MEMBERS OF THE BUREAU'S STAFF PUBLISHED IN OUTSIDE JOURNALS**

Experimental remineralization of dentin. Wilmer Souder and Irl C. Schoonover. J. Am. Dental Assn. (222 E. Superior St., Chicago 11, Ill.) 31, 1579 (December 1944). Reprints obtainable at 10 cents each from the American Dental Association Research Fellowship, Care of National Bureau of Standards, Washington 25, D. C.





